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Food and feeding habits of *Nemipterus japonicus* (Bloch, 1791) off Gujarat, north-west coast of India

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The food and feeding habits of *Nemipterus japonicus* (Bloch, 1791) were studied along the Veraval coast, Gujarat landed by trawl fisheries. Total of 179 samples were analyzed to study the food and feeding habits from August, 2017 to March, 2018**.** The gut content comprised of fishes, crustacean and molluscan indicating demersal carnivorous nature of feeding. During the study, 15 genera of various groups of animals and digested material were recorded from the fishes of 79-450 mm total length. Crustaceans were among the most preferred food items of *N. japonicus*, contributing to 51.71 % of IRI. The proportions of empty and full stomachs were 37 and 28 %, respectively. *Acetes* spp. was the dominant diet in feed with 26 % of total feed followed by digested material (21.55 %), *P. sanguinolentus* (12.06 %), and *Solenocera* sp. (11.35 %), respectively.

[**Keywords**: Food and feeding habit, Gujarat, IRI, *Nemipterus japonicus*, Veraval]

Introduction

Nemipterus japonicus belonging to the family Nemipteridae is conventionally known as "Ranifish"[1] and is distributed throughout the Indian Ocean. *N. japonicus* is schooling fish, occur abundantly in the shallow waters and prefers sandy and muddy bottom and are not migratory in nature. In Gujarati vernacular language, *N. japonicus* is locally known as 'Lal Machala' due to its color. It is mainly exploited by trawls operating at a depth of 35-70 m(ref. 2).

Threadfin bream fishery is among the major exploited marine fishery resources of Gujarat having good domestic and export demands. The total threadfin bream landings in Gujarat were 37,123 t in the year 2018, which was 30.79 % higher than the previous year (2017). The multiday trawlers (68.8 %) remain the main contributor in demersal fish landings followed by multiday dollnetters (8.7 %) and mechanized gill netter (6.3 %). Following the croakers, the threadfin breams were the dominant fish group in demersal fishery which was supported by *N. japonicus*, *N. mesoprion* and *N. randalli* along the Gujarat coast[3].

Tonnie *et al.*[4] studied the food and feeding habits of *N. japonicus* and *N. peronii* along the south china sea. During the study, 38.03 % of fish samples were found with full stomach in case of *N. japonicus* while in the case of *N. peronii*, only 27.05 % of fish samples were recorded with one-quarter full stomachs indicating poor feeding intensity in *N. peronii*. In Myanmar, Aung[5] studied the diet composition and feeding strategies of *N. japonicus* and observed that its diet was composed of 23 food items. Further, no significant changes in food were observed sex-wise as evidenced by their IRI values. Saraswati & Perdhana[6] studied the diet of *N. japonicus* caught in Blimbingsari waters, Banyuwangi, Java and recorded crustaceans as a main food [Shrimp (IP 62.55 %) and crabs (IP 26.03 %)] followed by squid (IP 5.92 %), brittle star (IP 2.37 %) and fishes (IP 2.85 %) as a supplementary food.

Along the Andhra-Orissa coast, the food and feeding behavior of *N. japonicus* was studied by Krishnamoorthi[7]. During the study, he recorded that the fish is undoubtedly a carnivore. He also stated that the feeding intensity of fish does not change with the increase in fish size but the category of food components was changed with size. Vinci[8] conducted a study on the biology of *N. japonicus* along the Kerala coast and observed that the fish does not cease feeding during the spawning season. Moreover, Shreekanth *et al.*[9] in a study on feeding characteristics of *N. japonicus* concluded that the Percentage Similarity Index (PSI) and Dietary Breath (DB) showed marked variation spatially along the east and west coast of India. They also observed a diversified

food items in the Cochin and Mumbai populations compared to Kakinada and Chennai populations wherein very few food items were recorded. Similarly, Manojkumar *et al.*[10] reported a total of 34 species in the gut contents of *N. japonicus* along the Malabar coast by analyzing 12,164 fish samples.

The biology of *N. japonicus* was studied by Suresh Kumar & Mohite[11] along the Rantagiri coast, Maharashtra, India and reported 19.2 % of specimens with empty stomach and 9.02 % with everted stomach showing regurgitation. The average proportion of gut contents reported were crustaceans (47.99 %), Fishes (31.07 %), Molluscs (6.66 %), polychaetes (1.13 %), unidentified matter (6.85 %) and semi-digested matter (6.27 %)[11].

Along the Gujarat coast, the fishery and biology of threadfin breams were studied by several researchers including Sen *et al.*[2], Devaraj & Gulati[12], Kizhakudan *et al.*[13] and Vagh *et al.*[14]. In a study by Gopal & Vivekanandan[15] recorded 43 and 28 % of the individuals of *N. japonicus* with an empty and full stomach, respectively from the Veraval coast, Gujarat. Similarly, Manojkumar[16] reported 52.43 % fish samples with empty stomachs. The poorly fed fishes were observed throughout the year except in April and December along the Veraval coast, Gujarat. Moreover, Thangavelu *et al.*[17] reported empty stomachs in all the size classes and with highest (41 %) in the size class 200-249 mm TL at Veraval coast, Gujarat. They also recorded Index of Relative Importance (IRI %) as Crustacean (84.7 %), fish (10.3 %), molluscan (3.8 %) and other miscellaneous items (1.2 %). Further, an increase in feeding intensity was recorded as spawning activity decreased at the Veraval coast by Raje[18].

The study on food and feeding based on stomach analysis is a routine practice in fish ecology[19]. The main purpose of this study is to find out the quantitative and qualitative estimations of food and feeding habits of *N. japonicus* in relation to month and length-classes from Gujarat waters. There is no specific study on the feed and feeding habits of *N. japonicus* at Gujarat coast for the last 10 years hence the study was proposed to check the similarity of the results with previous studies.

Materials and Methods

For the present investigation, fish samples were collected randomly from the multiday trawler from Veraval fishing harbour during August, 2017 to March, 2018. The samples were collected fortnightly by random sampling method and were then transferred to the laboratory in icebox to slow down the degradation process in the stomach. The total length, standard length, weight of fish and other morphometric parameters were measured and noted for the individual specimens. The dietary components were analyzed using the Index of Relative Importance (IRI)[20]. The IRI was computed as given below:

$$IRI = (\%N+\%V)\times\%F$$

Where, N = number, V = volume and F = frequency of occurrence.

The feeding intensity was determined according to the degree of distension of the stomach due to food items contained in it. All the stomachs were categorized as full, ¾ full, ½ full, ¼ full, trace and empty.

Feeding periodicity was calculated by analyzing the feeding intensity and the Empty Stomach Ratio (ESR). The ESR was calculated as per standard formula[21].

ESR (Empty Stomach Ratio) = Number of specimens with an empty stomach/Total number of specimens examined*100

Similarly, Stomach Fullness Index (SFI) was calculated by formula

SFI = Weight of stomach content/(Body weight – weight of stomach content)*100

Results

Feeding intensity

A total of 179 stomachs of *N. japonicus* of size range 79 to 450 mm (Total Length - TL) were examined. The fishes with an empty gut/stomach were observed in most of the months and on average, it forms 37 %. Full stomachs were also found in all the months with an average of 28 %, followed by 1/4, 1/2, 3/4 & trace comprising 13, 13, 7, and 2 %, respectively (Table 1). Percentage of the empty stomachs was higher during November - January because these months are considered as peak spawning season of *N. japonicus* and the feeding intensity increased thereafter, and hence the percentage of full stomachs was high during February and March. Monthly variation in feeding intensity of *N. japonicus* is presented in Table 1.

Frequency of occurrence of food items

The utmost recurrent dietary component observed in the diet of *N. japonicus* was *Acetes* spp., semi digested material, crustaceans, fishes and mollusks in

all the months (Table 2). It exhibited cannibalistic nature more frequently in September and November months. The diet of *N. japonicus* was composed of 16 prey items, which were categorized into 4 groups *viz*., crustaceans, fishes, mollusks and digested materials (Fig. 1).

Table 1 — Monthly variations in feeding intensity of *N. japonicus*

Month	Empty (%)	Trace (%)	One fourth (%)	Half (%)	Three fourth (%)	Full (%)
Aug-17	47.06	-	35.29	-	-	17.65
Sep-17	31.25	-	25.00	-	-	43.75
Oct-17	10.00	15.00	35.00	30.00	-	10.00
Nov-17	46.15	-	23.08	11.54	-	19.23
Dec-17	77.27	-	4.55	4.55	-	13.64
Jan-18	42.86	-	-	17.86	14.29	25.00
Feb-18	22.73	-	-	22.73	18.18	36.36
Mar-18	21.43	-	-	10.71	14.29	53.57
Annual	37.43	1.68	13.41	12.85	6.70	27.93

Table 2 — Monthly variations of IRI % in the dietary components of *N. japonicas*

Prey group	Months								IRI %
	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	
Thryssa sp.	8.23	34.66	-	-	-	-	-	-	5.36
Apogon sp.	18.95	5.48	5.21	1.55	-	2.90	-	3.50	4.70
Nemipterus japonicus	-	7.09	-	3.85	-	-	-	-	1.37
Saurida Tumbil	-	3.48	10.10	-	-	-	-	-	1.70
Bregmaceros sp.	-	12.25	-	-	-	-	-	0.99	1.66
Coilia dussumieri	7.07	-	-	-	-	-	-	-	0.88
Nemipterus mesoprion	18.95	-	15.52	-	-	-	-	-	4.31
Saurida undosquemis	-	-	6.81	-	-	-	-	-	0.85
Portunus hastatoides	5.15	-	-	-	-	2.90	3.97	-	1.50
Solenocera sp.	10.29	16.10	-	15.31	-	4.07	2.17	42.84	11.35
Acetes spp.	5.19	3.39	3.88	55.81	84.65	7.87	5.92	41.32	26.00
Portunus sanguinolentus	-	-	3.66	2.72	4.51	68.83	16.40	0.35	12.06
Squilla sp	-	4.80	-	-	-	1.64	-	-	0.80
Octopus sp.	-	-	-	13.20	-	-	10.00	8.74	3.99
Loligo sp.	-	-	3.13	3.96	-	-	8.26	-	1.92
Digested material	26.18	12.75	51.69	3.60	10.84	11.80	53.29	2.27	21.55
No of samples/month	17	16	20	26	22	28	22	28	

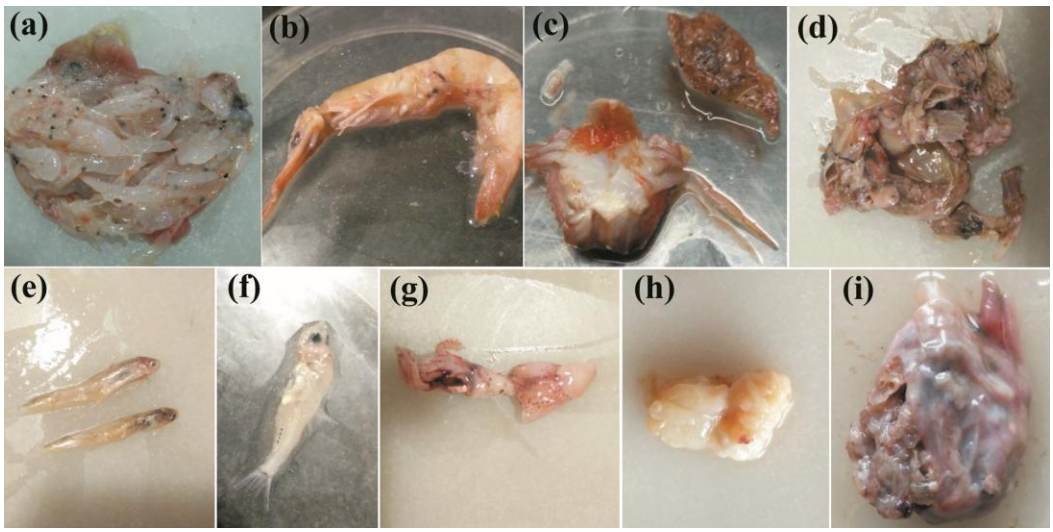

Fig. 1 — Dietary components of *N. japonicus* extracted from the stomach contents: (a-d) – crustaceans [(a) *Acetes* spp., (b) *Solenocera* sp., (c) *P. hastatoides*, and (d) *Squilla sp.*]; (e-f) – fishes [(e) *Bregmaceros* sp. and (f) *Apogon* sp.]; (g-h) – mollusks [(g) *Loligo* sp. and (h) *Octopus* sp.]; and (i) – digested material

Index of relative importance (monthly)

Variation in the Index of Relative Importance (IRI) of dietary components consumed by *N. japonicus* during study period indicates the variation in the availability and preference of food items in different months.

Crustaceans: Crustaceans were the chief preferred dietary component of the *N. japonicus* which contributes 51.71 % of IRI. Among the crustaceans, *Acetes* spp. (IRI = 26) followed by *Portunus sanguinolentus* (IRI = 12.06), *Solenocera* sp. (IRI = 11.35), *P. hastatoides* (IRI = 1.50), and Squilla (IRI = 0.80) showed major contribution. Crustaceans were the key prey items within which *Acetes* spp. was the most preferred prey items and was found in all the months with peak during November and December months. Crab, *P. sanguinolentus* was the second most dominant food item observed in the gut and was found in almost all the months except during August-September with the peak during January – February. Deep-sea shrimp, *Solenocera* spp., was also found throughout the study period excluding October and December with the peak during March. *P. hastatoides* and Squilla were observed in very fewer quantities.

Fishes: Fishes were the second-highest food group observed in the gut of *N. japonicus* (IRI = 20.83 %), including various species like, *Thryssa* sp. (IRI = 5.36 %), *Apogon* sp. (IRI = 4.70 %), *N. mesoprion* (IRI = 4.31 %), *Saurida tumbil* (IRI = 1.70 %), *Bregmaceros* sp. (IRI = 1.66 %), *N. japonicus* (IRI = 1.37 %), *Coilia dussumieri* (IRI = 0.88 %), and *S. undosquemis* (IRI = 0.85 %). Cannibalism was observed during the month of September and November.

Molluscs: Within molluscs, squid (*Loligo* sp.) and *Octopus* sp. were observed in the gut contents of *N. japonicus* with an average IRI of 5.91 %. % IRI values of squid and octopus were 1.92 and 3.99, respectively.

Digested material: Digested and Semi-digested materials (IRI = 21.55 %) were noticed in all the months with the peak during October and February months.

Index of relative importance according to length class

During the study, 179 stomachs of *N. japonicus* were examined. Changes in the feeding intensity of *N. japonicus* according to fish size (TL) are depicted in Figure 2 which shows ontogenetic shift in the selection of food. The present investigation suggested that the fishes with a small length class prefer small crustaceans and molluscs whereas fishes with higher total length were found with teleost fishes and larger crustaceans in their stomach. The occurrence of teleost fishes was observed in the stomach of *N. japonicus* at 161 mm (TL) size and above which was found to upsurge with the size of fish.

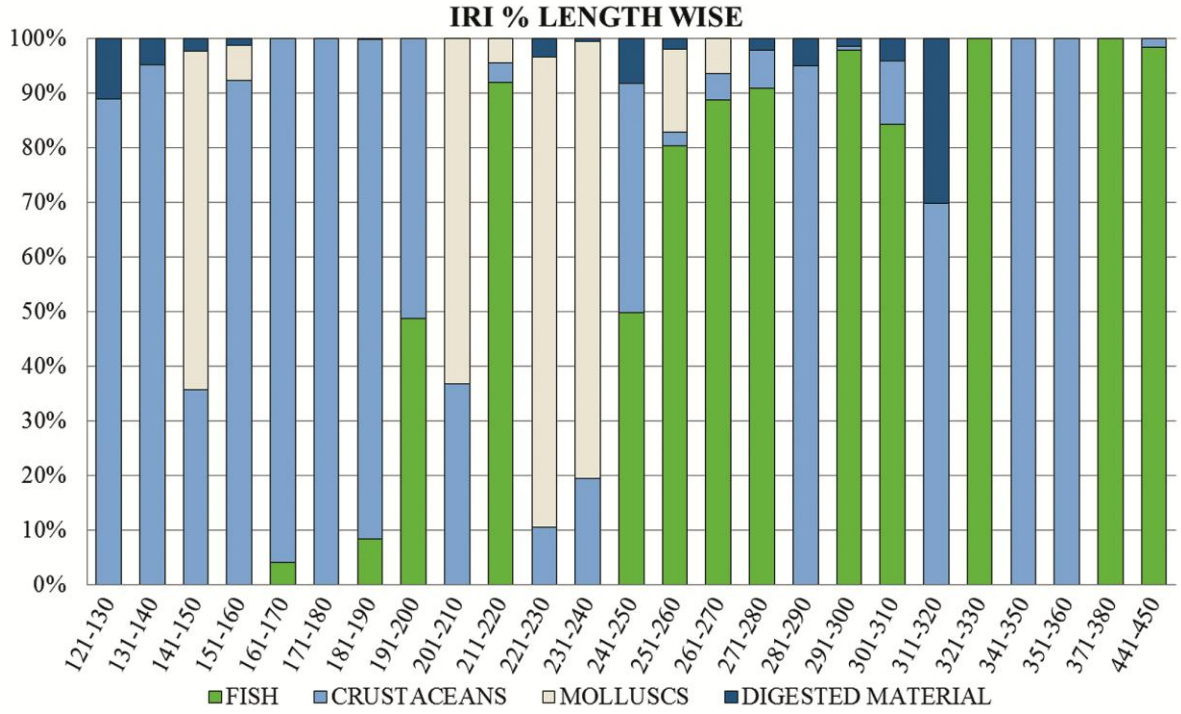

Fig. 2 — Length class (mm) wise variations of IRI in the dietary components of *N. japonicus.*

Empty Stomach Ratio (ESR)

Empty stomach ratio of male and female specimens was calculated as per formula and ranged from 0 to 83.33 for males and 14.28 to 70 for females (Fig. 3a)

Monthly variation in fishes with full stomach

Monthly variation in male and female *N. japonicus* with full stomach percentage was plotted and it ranged from 8.33 to 87.5 in male and 0 to 50 in the female. (Fig. 3b)

Stomach fullness index

Stomach fullness index was calculated month wise for the study. The highest value (3.00) was recorded during March while the lowest (1.10) was observed during December. SFI in male and female was reported as 2.12 and 1.65, respectively. The SFI value in immature male and female was 2.85 and 2.28, respectively while in case of mature male and female the value was 1.58 and 1.29, respectively (Fig. 4).

Discussion

The present investigation confirms that the *N. japonicus* is a demersal carnivorous feeder which prefers to feed upon crustaceans, fishes and mollusks as food. Among them *Acetes* spp., *Solenocera* sp., crabs and teleost fishes formed the principal diet, and this species also show a cannibalistic feeding nature to some extent. The dietary component of *N. japonicus* includes crustaceans, teleosts, polychaetes, annelids, molluscs and echinoderms[18,22]. Earlier studies revealed that crustaceans including squilla, crabs, shrimps (*Acetes* spp., *Solenocera* sp.,); fishes such as sciaenids, *N. japonicus*, *N. randalli*, *Lactarias lactarias*, *Apogon* sp., *Secutor* sp., *Trichiurus* sp., *Myctophum* sp., *Cynoglossus* sp., *Saurida* sp., *Leiognathus* sp., *Bregmaceros* sp.; polychaetes like *Nereis* sp.; and cephalopods like cuttlefishes and octopus are frequently encountered in the diet of *N. japonicus*[1,4-11,15-18,24]. Further, Kuthalingam[1], Raje[18] and Sudheesan *et al.*[23] have also reported the cannibalistic feeding behavior of this species.

Rao[24] and Gopal & Vivekanandan[15] have observed the crabs and prawns as major food items of *N. japonicus* off Waltair. At Veraval, the dietary components consist of *Acetes* spp., squilla, penaeid prawns, crabs, deep-sea prawns, and juveniles of fishes such as flatheads, lizard fishes and fish larvae as reported in present study and by Manojkumar[16]. The various study reveals that the fish is indubitably a carnivore which actively preys upon crustaceans, molluscs, annelids and echinoderms[7,8,22,25-27]. During the present study 15 genera of animals and digested material were observed from the fish stomachs.

According to Blaber[28] diets of most fishes changes with size. The alteration in dietary component is widespread among fishes due to its capability to prey upon larger individuals with increase in the size of body and mouth[29]. During the present study too, the alteration in the selection of food was observed with increase in fish size.

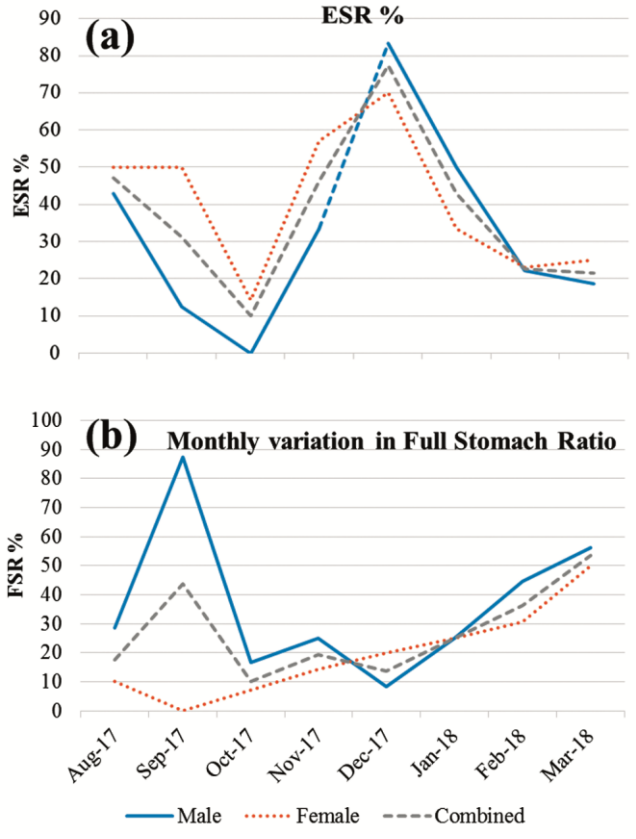

Fig. 3 — a) Monthly variations of empty stomach ratio (ESR) and b) full stomach ratio (FSR) of *N. japonicas*

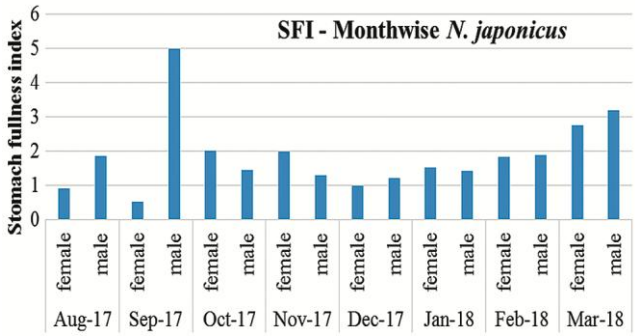

Fig. 4 — Monthly variation of SFI in male and female *N. japonicus*

Teleost fishes are the most preferred food item of *N. japonicus* as they grew. They feed on a broad spectrum of diet during their early life span which becomes narrower as they grow and become a more active predator and selects large crustaceans and fishes as their feed[10]. *N. japonicus* is carnivorous fish which shift their diet from shrimp to crabs, and then to fish as they grow[4,30,31]. During the present study, teleost fishes were observed in the stomach contents of *N. japonicus* at 161 mm (TL) size and above. The higher proportion of fishes in the gut was observed with the increase in size of the fish.

The IRI value in the study is in agreement with Manojkumar *et al.*[10] who concluded that the crabs and squilla were the most preferred food items of juveniles and sub adults.

Empty Stomach Ratio (ESR) in the fish was high in November, December and January. Accordingly, highest spawning was also observed during the November to January during the study so either it might be the reason for higher ESR during November to January[15] or non-availability of preferred food items during those months can be the reason for the same. Similarly, higher ESR was recorded in January by Tonnie *et al.*[4] in the South China Sea. Similarly to the result observed by Raje[18] higher stomach emptiness observed in females than in males in most of the months from Veraval waters.

Stomach fullness index were analyzed for male and female which showed higher value in male compared to females which might be due to spawning season female prefer less food than the male. SFI value for the mature and immature specimens were calculated to estimate the impact of maturity on the status of stomach which shows the immature specimens observed with higher SFI value compared to mature specimens which might be due to more gonadal development in mature specimen compare to immature specimens. Month wise SFI values were estimated which shows higher values in March while lowest value was observed in December. The Lowest value of SFI in December also negatively correlate with spawning percentage which was highest in December during the present study[15].

The result of the study indicates that the *N. japonicus* is a carnivorous feeder preying mostly upon crustacean, fishes, and molluscs. *Acetes* spp. forms the most preferable prey item, however seasonal variation is also observed in the feeding intensity with some sort of cannibalism during post-monsoon months. A high empty stomach ratio was observed during the post-monsoon months due to higher spawning percentage during post monsoon. The feeding intensity was higher during the winter season which is also the period of maturation of the fish. The variation in the diet might be due to the availability of the prey items specially *Acetes* spp. during the juvenile stages and might be due to the nutritional needs during the later stages. The results of the present study will be useful for fishery managers to predict the catch from the availability of their prey items.

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Conflict of Interest

The Author(s) declare(s) that there is no conflict of interest.

Author Contributions

SV, HKK & VV conceptualized the research experiment and conducted the research and drafted the manuscript; while MP, N (Neelmani), DM & VR assisted in data collection and transportation of the fish from landing center to laboratory and data analysis.

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